U.S. DEPARTMENT OF ENERGY

OFFICE OF SCIENCE

Closeout Report on the DOE/SC Status Review of the

Long Baseline Neutrino Facility/Deep Underground Neutrino Experiment (LBNF/DUNE) Project

Fermi National Accelerator Laboratory

March 20-22, 2018

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Committee Chair

Office of Science, U.S. Department of Energy

http://www.science.doe.gov/opa/

Review Committee Participants

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SC1 Beamline	SC2 Detectors	SC3 Cryogenic	SC4 Conventional Facilities
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Bob Garnett, LANL	Kevin Lesko, LBNL	Kelly Dixon, TJNAF	Adrienne Carney, U of Pitt
	Blair Ratcliff, SLAC emeritus		Chris Laughton, TechSource Inc.

SC5 Environment, Safety and Health	SC6 Cost and Schedule	SC7 Project Management
* Ian Evans, SLAC	* Ron Lutha, DOE/CH	* Jim Krupnick, retired LBNL
Frank Kornegay, retired ORNL	Mike Fenn, DOE/PM	Kurt Fisher, DOE/SC
	Jennifer Fortner, ANL	Gil Gilchriese, LBNL
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Observers

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LEGEND

SC Subcommittee
* Chairperson

Count: 21 (excluding observers)

Charge Questions

1. Is the project making sufficient progress to give confidence that CD-2 can be achieved by December 2019? Are there adequate resources in place to complete the work needed for CD-2?

2. Is the DUNE collaboration's plan to complete its technical design by CD-2 reasonable and achievable? Have they identified the resources needed to carry out that plan? Has Fermilab provided the technical and management support to the DUNE collaboration consistent with its host lab role? In particular, assess the progress by US DUNE in defining US contributions to the DUNE experiment.

3. Is the program to construct, install, and operate prototype liquid argon TPCs at CERN making appropriate progress to inform the DUNE design?

4. Is the work on the scope approved at CD-3a proceeding as planned? Are procurements being executed in an efficient and timely manner?

5. Are the requirements, the design and the interfaces pertaining to the far site conventional facility CD-3a scope under effective configuration control and management?

6. Are all ES&H organizations, plans, and resources adequate to effectively address all aspects of ES&H for all project activities at all project locations?

7. Is the LBNF/DUNE project being appropriately and effectively managed, including risk and contingency? Does the tailoring strategy provide concrete benefits in lowering the risk or cost and improving the schedule without significant management complications?

8. Has the project responded appropriately to recommendations from past reviews?

Charge questions

1. Is the project making sufficient progress to give confidence that CD-2 can be achieved by December 2019? Are there adequate resources in place to complete the work needed for CD-2?

No, but they continue to make good progress moving the design along considering the budget constraints and there is a clear plan for how to advance the design to the preliminary level and beyond.

6. Are all ES&H aspects of the beam-line project being adequately addressed?

Yes. It appears that most ES&H aspects for the beamlines project are appropriately being addressed given the maturity of the design

8. Has the project responded appropriately to recommendations from past reviews?

Yes, most recommendations have been addressed. The beamline project appears to be working to a well-defined project plan and has improved interactions with international partners.

Findings

- We were very impressed with the preparations done for the review and the quality of the presentations. With short notice, additional presentations on priorities and accident scenarios were prepared which was much appreciated. It is clearly a small but well-motivated and competent team.
- The beamlines project faced a major change in 2017 with the adoption of a new optimized target and horn design which significantly improved the physics reach. This set the the design maturity back and they have with the limited resources available worked hard to recover this loss of design maturity.
- The beamline optimization has been to the price of an increased cost to the project.
- The beamline has adopted the RAL target design after a careful study. The new design should increase reliability and it is also the beam-lines most important IK contribution.
- Good progress is being made on the RAL target design but may be delayed due to funding timelines. However, there are frequent interactions with RAL on the target milestones.
- The change of target and the new optimized beamline has had impact on the target chase design which is being addressed.
- The absorber design is also impacted by the beamline optimization and this is being addressed.
- The decisions is to use nitrogen for the target chase to reduce activation and reduce the risk for oxidization, good progress has been made on the design of the nitrogen filled chase.

Findings (cont.)

- The beamlines project will not reach preliminary design level for CD-2 but they continue to make good progress moving the design along considering the budget constraints, but almost all aspects of the beamline effort are delayed beyond the present CD-2 date in 2019. The only exception is the primary proton beam line design. Still, there is a clear plan for how to advance the design to the preliminary level and beyond.
- Staffing for the beamline is still an issue due to budget constraints. There is a moderate project risk identified related to inadequate engineering staffing.
- The plan for the remainder of FY18 is to incrementally increase staffing from the current 4 FTE level to approximately 12 FTEs for the remainder of FY18. Additional funding to support this short-term increase in beamline staffing is in hand but identified resources have yet to be made available. There is also an issue with previously engaged staff having left for other activities at FNAL.
- The project plan assumes that all design lag catches up before CD-3 implying that many tasks that should be at preliminary design and proceeding towards final design before CD-3 will still be in progress. This presents both budget and schedule risk that which needs to be considered and appropriate contingencies assigned.
- It appears that most ES&H aspects for the beamlines project are appropriately being addressed given the maturity of the design. The highest risk is tritium mitigation. It is being addressed adequately.
- Other safety aspects such as faults and system or component failures are also being proactively addressed

Findings (cont.)

- The beamline is being appropriately and adequately managed, including risk and contingency but the Beamline budget and schedule risks associated with not meeting CD-2 requirements on schedule needs to be re-evaluated. This includes impacts related to in-kind (non-DOE) deliverables.
- The beamline project is working to a well-defined project plan and has improved interactions with international partners.
- Several examples of value engineering were presented that demonstrate the project is looking for ways to reduce cost and risk.
- It was acknowledged that a new cost estimate needs to be completed but is not expected until FY19 just before CD-2.
- Finding new partners for in-kind (IK) contributions is still a major issue that could eventually impact project cost contingency and add additional DOE scope.
- Beside the main IK contribution for RAL, there is also an IK contribution from China for corrector magnets and discussion are on-going with other countries.
- The beamline to-date has only secured about 11 M$ in IK and is according to the project plan supposed to have 70 M$ in IK which represents 34% of the project budget.
- The increase in IK was a way to mitigate the effect of the cost increase for the optimized beam line lay-out. IK does not require the Project to set aside contingency money so increasing IK freed contingency money which could be allocated to the new optimized beamline layout.

Comments

1. The new optimized beam-line design which has increased physics reach significantly did set back design maturity from 55% in February 2017 to 37% in March 2018.

2. A significant effort has been made since the Feb 2017 DOE IPR with modest FY18 funding to catch up on lost design maturity and advance the beam-lines design. The majority of the effort was focused on beamline optimization with changes to the target chase and hadron absorber facilities. The team continues to work towards major design decisions and risk reduction including advancing the neutrino target design with RAL and furthering simulations to support the optimized horn designs. The main focus will be towards achieving CD-2 in Dec 2019. However, many tasks will not be at PDR level so careful attention should be paid to cost and schedule contingencies. We want to stress that there is a clear plan for how to advance the design to the preliminary level and beyond.

3. Preliminary design work for the Target Shield Pile started in FY18. Design is conceptual and estimated 45% complete. FY18 funding limitations have impacted the design effort. Many system components are outside DOE scope of work. Design is proceeding towards CD-2 but is being slowed until new outside partners are identified and designs are more mature. Interfaces with some sub-systems (target, horns, beam window, etc.) is an issue but the plan is to mature the design in areas where more advanced/mature interfaces exist. The recent optimized design that includes the addition of a 3rd horn has required reconfiguration of components and shielding. Still, there is a clear plan for how to advance the design to the preliminary level and beyond.

Comments (cont.)

4. There is not yet a full mitigation strategy for tritium handling, although studies are underway to reduce risk during preliminary design to meet the strictest requirements. Tritium release from the target pile shielding is significant. The plan is to get a better understanding from NuMI data and to develop an appropriate mitigation strategy.

5. A significant increase in funding is expected in FY19. Ramping up staffing to the expected level based on this funding profile may be an issue. FNAL management should consider proactively planning for the FY19 budget uptick which predicts a significant increase in beamline staffing that presumably will come from FNAL-internal resources.

6. Finding new IK partners is a time-consuming ”salesman task” which can’t be done only by mail, video conferencing and phone calls. In-person visits are not only necessary as a way to follow up on first contacts but also as a form of evaluation of what the potential partner can do.

7. It was not clear how unexpected issues related to integrating components and systems from IK partners will be assessed and mitigated.

Comments (cont.)

8. The risks associated with non-DOE contributions (IK) should be captured in the risk register even if DOE doesn't carry contingency money for it. Risk workshops with IK partners will help capturing these risks and also determine ownership for risks at the interface between IK and DOE scope.

9. There is a risk that the potential IK partner interest will decrease as the design matures at FNAL as there is less added value for the IK partner. This will increase the risk for FNAL to have to self-perform. A possible added value, is a strong interest at the potential IK partner for future physics users of LBNF/DUNE.

10. Many IK partners will have many competing priorities and it is very hard to influence their priority setting which can e.g. be an issue of national priorities set well above IK partners management structure.

Recommendations

1. Begin efforts in FY18 to lower the high risks related to horn fabrication and processing which are the biggest beamline schedule risk drivers,

2. Decide and agree on priorities with the project management for the beamline work before CD-2. This is to ensure that project management can reach its objectives of baselining the full project for CD-2. FNAL management should make identified resources available immediately to best use additional FY18 funds (1M$, available now).

3. Planning should begin immediately by FNAL management to make appropriate resources available in FY19 to aggressively move the beamline design to the preliminary design level.

4. Set-up an IK task force now (April-18) to look for new IK partners and be ready to spend travel money to visit potential IK partners. In-person meetings and workshops such as the one planned at CERN have proven to be the best way to find new IK partners.

5. Capture the risk that the lack of IK partners represents now (April-18; only 11 M$ secured out of 70 M$ required for beam line). The risk is to have to self-perform which will require changes in resources at FNAL and will require additional contingency which isn't part of IK.

6. Assure now (April-18) that schedule contingency is assigned to all IK contributions. Experience shows that the cost can successfully be kept fixed as agreed in the IK contract but it is much harder to control the schedule.

1. Is the project making sufficient progress to give confidence that CD-2 can be achieved by December 2019? Yes. Are there adequate resources in place to complete the work needed for CD-2? Likely yes.

2. Is the DUNE collaboration's plan to complete its technical design by CD-2 reasonable and achievable? Yes; options will likely remain in the CD-2 elements for the far detector; other elements will be mature and capable of passing CD-3b. Have they identified the resources needed to carry out that plan? DUNE-US has; international DUNE has a solid plan. Has Fermilab provided the technical and management support to the DUNE collaboration consistent with its host lab role? Yes and no. Technical support for TDR: yes. Integration and coordination is developing. In particular, assess the progress by US DUNE in defining US contributions to the DUNE experiment. The DUNE-US contributions to the far detector are adequately defined. No plans for the near detector were presented.

3. Is the program to construct, install, and operate prototype liquid argon TPCs at CERN making appropriate progress to inform the DUNE design? Yes, with no schedule float for CERN test beam.

8. Has the project responded appropriately to recommendations from past reviews? Partially.

- **Findings**
  - The committee thanks the collaboration and detector team for the interesting talks about the DUNE Project, and for the informative exchanges. The science collaboration has continued to grow at a rate of about 100 members per year, and is now approaching 1,100 members. The detector project management team is strong.
  - The SP (single-phase) ProtoDUNE construction project is within view of completion. The last APA (Anode Plane Assembly) is scheduled to arrive at CERN in early April, 2018 after completion at PSL (the University of Wisconsin Physical Sciences Laboratory). Cold electronics is in hand, the cryostat is due to be closed in mid-June, and various commissioning activities are planned to take place over summer, 2018; CERN test beams are planned to be available between 29 August and 11 November. The collaboration is on track to operate the SP ProtoDUNE detector in 2018 and collect the data that will inform the final Far Detector designs.
  - Analyses for the data will be challenging; meeting the project milestones for the TDR in 2019 is plausible.

- **Findings (cont'd)**
  - The 2018 SP ProtoDUNE construction budget is approximately 30% higher ($27.6M) than presented at the last IPR in February, 2017 ($20.6M). The schedule for receiving all 6 APAs by ~ December 2017 slipped slightly, possibly resulting in one APA having to be installed without cold testing.
  - SP ProtoDUNE will
    - Use current cold electronics designs, selecting ADCs from original order of 5000 to find 900 acceptable units
    - Use advanced APA designs fabricated in the US and UK
    - Maintain the three dominant goals of:
      - The demonstration of construction and assembly techniques
      - The achievement of acceptable operation parameters
      - The delineation and demonstration of detector performance criteria
    - Provide operational experience from cosmic ray running
    - Inform physics characterization with beam runs
  - The SP ProtoDUNE beam-plug has been shown to not degrade detector performance and is expected to enhance physics characterization of SP ProtoDUNE.

- **Findings (cont'd)**
  - The international DUNE collaboration has substantially refined its organization in the past year, and has broadly adopted LHC organization models. The far detector construction project scope has been organized into 9 consortia, overseen by technical coordination, which provides the structure for interface development among the collaborating agencies including LBNF. There are now regular meetings of senior DUNE management, consortia leadership, and other key leaders.
  - The far detector consortia are in place and moving forward with the key activities needed to be ready for the release of the TDR in 2019.
  - The TDR for CD-2/3b has been organized by the international DUNE collaboration, and first drafts of the technical proposal, which will evolve in to the TDR, have been completed. International DUNE plans to submit the TDR to the Long Baseline Neutrino Committee (LBNC) for review in April, 2019.
  - The current plan is for 2 of the 4 DUNE far detector modules to be SP, 1 to be Dual Phase (DP), and 1 provides opportunity for an advanced detector technology. The US scope for CD-2/3b incorporates contributions towards 2 far detectors.
  - The DUNE-US scope is principally in the SP detector construction, and is largely well defined. The international negotiations to finalize all scope are being actively pursued, and might result in final DUNE-US scope modification.

- **Findings (cont'd)**
  - The DP detector(s) are mostly outside of the US DUNE scope.
  - A model for funding operations, a common-fund, and host-lab responsibility was presented.
  - The cold electronics is DUNE-US scope. To resolve issues in the first round cold electronics (specifically the ADC), the collaboration established a task force bringing experts from FNAL, BNL, LBNL, and SLAC. The task force has issued a report and the collaboration is following those recommendations.
    - Noise on front end electronics (FEE) needs to be <<1000 e- to exploit DUNE's full physics program
    - Noise on FEE being installed in SP ProtoDUNE is estimated to be ~500 e- per channel.
    - The cold electronics task force brought additional electronics expertise to the collaboration (LBNL and SLAC/nEXO).
    - The TDR may forward more than one design for the ASIC while subsequent R&D is conducted.
    - The cold electronics and APAs will likely require 100% cold testing before deployment in DUNE using a coldbox or equivalent.

- **Findings (cont'd)**
  - A portion of the APAs (Anode Plane Assemblies) is DUNE-US scope; the remaining scope is in DUNE-UK. The coordination between US and UK has been excellent in successful fabrication and delivery of the SP ProtoDUNE APA, with many lessons learned that have greatly reduced risks in producing the DUNE APAs.
  - The DUNE PDS (Photon Detection System) is likely to be outside of DUNE-US scope. 58 of the photon detectors in the SP ProtoDUNE were supplied by the DOE base program and DUNE-US, and the remaining 2 included substantial non-US effort.
  - Working with the 35-T experiment and data from earlier efforts, understanding of the performance of the HV (high voltage) performance used to provide the drift field has advanced considerably.
  - No detector has demonstrated long-term stable operations at 180kV, the goal for DUNE.

- **Comments**
  - We commend both DUNE-US and the DUNE collaboration for their efforts and substantial progress on the SP ProtoDUNE detector construction. These efforts establish a solid foundation for DUNE planning, and greatly reduce risks that will be delineated in the CD-2/3b approval process.
  - We commend the DUNE collaboration for its establishment of an organization that we believe can lead to completion of TDR and the successful US DOE CD-2/CD-3b approvals.
  - US base research support has been critical for the DUNE effort, and is key for future DUNE success.
  - We did not hear about the ND (near detector) design or progress. Ownership of the ND is important to proceed on the definition of key parameters which impact conventional facilities.

- **Comments (cont'd)**
  - We commend DUNE-US for the cold electronics task force and its success in identifying solutions to the issues found with the original ADC.
  - The PDS (photon detection system) requirements are not complete. There is a need to perform further R&D; options may need to be carried through the TDR.
  - We advise the DUNE collaboration and the science agencies to carefully weigh the operations funding model.
  - We did not hear about the DP detector design or progress.

- **Recommendations**

1. Ensure operations of SP ProtoDUNE adequate to capitalize on the investments and to inform the TDR and the preparations for CD2/3b review on the detector operations and characterization, in part by closing the second recommendation of the 2017 IPR.

2. Document the lessons-learned from the various SP ProtoDUNE efforts and compare these to the initial goals (constructability, operations and performance) in a report completed prior to submission of the TDR to the LBNC in April, 2019.

3. Continue R&D on detector HV performance with a goal of achieving stable 180 kV operations by the time of the CD2/3b review.

4. Evaluate the impact of photon detection, HV performance, liquid argon purity, and detector operations on the low energy physics program and include in the TDR, in part by closing the fifth recommendation from the 2017 IPR.

- **Recommendations (cont'd)**

5. Continue essential R&D on cold electronics to ensure optimization by CD2/3b including selection of hybrid package or simply replacing the ADC.

6. Establish an independent focused review of the cold electronics prior to making the final selection of technology for the CD2/3b review.

7. Establish an independent focused review of the photon detection system prior to making the final selection of technology for the CD2/3b review.

8. Continue efforts to assign ND scope; independent of that process establish a task force to expeditiously establish essential parameters impacting the physics program and CF.

2.3 Cryogenic

M. Howell, ORNL, K. Dixon, JLab

Subcommittee 3

1. Is the project making sufficient progress to give confidence that CD-2 can be achieved by December 2019? Yes, CD-2 can be achieved by December with adequate resources. Are there adequate resources in place to complete the work needed for CD-2? No, additional resources are needed.

3. Is the program to construct, install, and operate prototype liquid argon TPCs at CERN making appropriate progress to inform the DUNE design? Yes, the prototyping effort with respect to the cryogenic design is making adequate progress to inform the project.

6. Are all ES&H organizations, plans, and resources adequate to effectively address all aspects of ES&H for all project activities at all project locations? Yes, the ODH analysis looks complete and aspects of managing that system have been added to the WBS.

8. Has the project responded appropriately to recommendations from past reviews? Yes.

- **Findings**
- **Definition of subsystems**
  - **Infrastructure Cryogenics (INF):**
    - Receive Ar/N2.
    - Transport Ar to cavern.
    - Nitrogen System (LN2 refrigeration + LN2 storage dewar)
    - LN2 distribution system.
  - **Proximity Cryogenics (PROX) :**
    - Circulate and purify LAr.
    - Achieve and maintain LAr purity.
    - Recondense boil off GAr and purify GAr (boil off and purge).
  - **Internal Cryogenics (INT):**
    - Inside the cryostat.
    - Cryostat purge, cool down, fill.
    - GAr/LAr distribution.

- **Findings**
  - **Infrastructure Cryogenics** → Detector Cavern and Central Utility Cavern (CUC) and surface. Main items:
    - Cryogens receiving stations (surface).
    - GN2/GAr piping in the shaft.
    - Full LN2 refrigeration system (surface, underground).
    - LN2 storage dewars (underground).
    - Interconnecting piping, buffer tanks, valves, instrumentation, etc. (surface, underground).
  - **Proximity Cryogenics** → Detector Cavern and CUC. Main items:
    - LAr circulation pumps (detector cavern)
    - GAr and LAr purification filters with regeneration system (CUC)
    - Condensers for the boil off GAr, LAr/LN2 phase separators (detector cavern).
    - Interconnecting piping, buffer tanks, valves, instrumentation, etc. (detector cavern + CUC).
  - **Internal Cryogenics** → inside the cryostat. Main items:
    - Manifolds for the purge (GAr), cool down (LAr/GAr + GAr).
    - LAr return.
    - LAr withdrawal.

- **Findings**

Item	Detectors #1, #2	Detectors #3, #4
Cryostat	CERN (1) + Non-DOE (1)	Non-DOE
Cryogenics Systems Integration	DOE	DOE
LN2 Refrigeration System Design/Integration	DOE	DOE
LN2 Refrigeration System Fab/Installation/Com	DOE (3 units)	Non-DOE (1 unit)
LN2/LAr Receiving Facilities (surface)	DOE	DOE
LN2 Storage dewars (underground)	DOE	DOE
LN2/LAr Piping	Non-DOE	Non-DOE
Proximity Cryogenics in CUC	Non-DOE	Non-DOE
Proximity Cryogenics on Mezzanine	Non-DOE	Non-DOE
LAr Pumps	Non-DOE	Non-DOE
Internal Cryogenics Design/Fab/Installation	DUNE	DUNE
Collect safety docs and obtain safety approval	DOE	DOE
Purge and cool down	DOE	Non-DOE
LAr procurement	DOE	Non-DOE

- **Findings**
  - Since last review, the liquid nitrogen storage has been moved back to the CUC.
  - The cryostats, ProtoDuneSP, ProtoDuneDP, and Cryostat 1 are being built to a guideline document signed by FermiLab and CERN (EDMS 1554082).
  - An innovative methodology of construction of the cryostat has been developed to minimize welding and save manpower.
  - There are approximately 240 penetrations on the SP cryostat and 480 on the DP. This makes these cryostats unique from other cryostats built for industry.
  - The assembly sequence for the cryostats has been developed.
  - ProtoDune is 1/25th the size of the final detector cryostat.
  - The cryostat manufacturing company has performed well and instilled confidence. The same company that is designing the membrane cryostat for ProtoDune will be used to design the membrane for the final detector cryostat.
  - CERN has good experience with the performance of a cryostat cleaning company.
  - No leaks were measured in the ProtoDune cryostat. However, some welds were repaired based on inspection

- **Findings**
  - Destructive testing is being completed on prototypes of seven high stress areas.
  - Applying all engineering methodology and acceptance criteria to ProtoDune.
  - The head pressure of the argon in the cryostat is 2 bar.
  - Proto-dune prototype design pressure and LBNF cryostat is 0.35 barg. The relief device has been set at the maximum design pressure.
  - Cryostat insulation is a polyurethane and fiber structure with an inert blanket. It, with the steel outer structure, provides the structure against the thin, ½" thick pressure barrier.
  - Host lab owns ODH analysis and changes that may occur when partners deliver equipment
  - There are no cryogenic connections to allow servicing equipment. There are no bayonets
  - SURF has some ODH experience and are familiar with the Fermi system
  - The SURF ODH SME sits on the LBNF safety panel
  - AP is 60 days behind schedule.

- **Findings**
  - The oil removal skid is not shown on the compressor room drawings.
  - Argon purity has been demonstrated using similar purification methodology on smaller detectors. The largest so far is MicroBoone at 170T of LAr. ProtoDune will be the next test of the purification system on a 765T LAr detector.
  - The proximity cryogenics systems have been divided into design packages for non-DOE potential contributors
  - Purity monitoring of LAr is in non-DOE scope
  - The RFI and industry day at SURF resulted in good interaction with Argon vendors and it is planned to continue similar efforts annually until 2023.
  - As a result of interfacing with the Argon vendors, the delivery schedule was modified to reduce the peak delivery period and shorten the gaps of no deliveries. This smoothing of the Argon delivery schedule is more appealing to the vendors.
  - The RFP for LAr will be issued two years ahead of start of supply.

- **Findings**
  - Controls integration is included in the Cryogenic Infrastructure scope and this aspect is still in conceptual design.
  - The integration of all cryogenic components and subsystems is in the DOE scope.
  - Purifier bed internals inside argon purification systems may be damaged if relief valves lift with present design.
  - Limited storage area available at the site. All deliveries must be just in time.
  - Hot water vaporizers are used.
  - Refrigerators are sized for the steady state purification with some margin.
  - The LBNF cryogenic systems staff consists of 3 full time engineers and 2 designers but needs 3-4 more people. This is not currently in the staffing plan.

- **Comments**
  - The project staff should be commended for the amount of work completed with limited available resources.
  - The design of the unassigned non-DOE scope has advanced despite partners not having been identified.
  - The project is under staffed and this is affecting the cryogenics and controls integration efforts.
    - The controls integration effort is in the infancy stage and needs to be advanced in coordination across all technical systems.
    - The integration of all cryogenic subsystems requires substantial effort to reach the level of CD-2.
  - It requires considerable effort to accommodate and facilitate international participation to benefit the project (codes and standards, safety identification and resolution, specifying interface points in scope, clearly defining host lab responsibilities, agreeing to schedule with partners, approving drawings and design, detailed MOUs etc.)
  - Procurement of the N2 refrigeration systems is behind schedule and is selected for DOE MA review which is expected to add more time to the process.

- **Comments**
  - Integrating documentation from various partners could present challenges and will be the responsibility of the host laboratory. Specifying the documentation delivery could minimize effort later in the project.
  - Oil back streaming should be considered in the design packages for the compressors.
  - It is not clear how destructive testing on prototyped pieces of high stress areas can fully substitute a pneumatic test for the cryostat.
  - No bayonet connections are planned. Positive isolation methodology should be detailed by CD-2 if the detectors/cold boxes or 24 N2 dewars had to be disconnected from the system.
  - The presentations for the cryogenic systems were geared to achieving CD-2. There was not emphasis towards meeting CD-3B despite the project schedule showing that they are issued simultaneously.

- **Recommendations**
  1. Immediately identify resources needed to advance the design to CD-2, submit a project change request, and add those resources to the Cryogenic team.

3. Conventional Facilities

J. Stellern SLAC, A. Carney, C. Laughton
Subcommittee 4

1. Is the project making sufficient progress to give confidence that CD-2 can be achieved by December 2019? Yes for the Far Site. The near site preliminary design will not be complete at CD-2. Are there adequate resources in place to complete the work needed for CD-2? Yes, with plans for progressive hiring as required.

3. Is the program to construct, install, and operate prototype liquid argon TPCs at CERN making appropriate progress to inform the DUNE design? Yes

4. Is the work on the scope approved at CD-3a proceeding as planned? No, final design and field work is starting later than planned. Are procurements being executed in an efficient and timely manner? No, There have been delays in the award of contracts. Procurement is working to increase staff and improve their performance. Refer to the management section.

5. Are the requirements, the design and the interfaces pertaining to the far site conventional facility CD-3a scope under effective configuration control and management? Yes

8. Has the project responded appropriately to recommendations from past reviews? Yes

Findings

- Far site final design and construction is starting later than planned but these tasks have been replanned using baseline change requests.
- Far site preliminary design is complete, near site conceptual design has been updated.
- The RFP for the far site final design is at DOE for approval.
- Far site CM/GC contract was awarded to Kiewit/Alberici JV in August 2017.
- CM/GC has reviewed the preliminary design and provided a significant number of comments to Fermi and ARUP for responses and incorporation into the final design.
- Near site AE and CM/GC are not scheduled for award until mid 2019.
- The CM/GC, Fermi, ARUP and SDSTA have held their first partnering session.
- CM/GC base award includes design support and procurement of pre-excavation construction tasks through the bid process. Construction of the pre-excavation tasks will be included in the future CM/GC Option 1A award.

Findings

- SDSTA has three reliability projects in process but the Ross Shaft Rehabilitation is on hold due to a safety incident. SDSTA has several other upcoming reliability projects.
- CM/GC will be managing all of the pre-excavation tasks as self performed or bid to subcontractors. Option 1A of their contract needs to be awarded prior to the start of any field work.
- Conventional facilities have adequate staff for the current effort and plan to add staff in the future, as construction increases at the site.

Findings - Near Site

- Site investigation has been performed for the upstream structures. (Main Injector to Absorber Hall).
- It is planned to perform site investigation for the Near Detector Hall once the Hall footprint is confirmed in May 2018.
- The conceptual design work has drawn extensively on Fermilab's prior experience constructing cut-and-cover and mined structures at the site in the same ground units.

Findings - Far Site

- Ross Shaft rehabilitation has been completed down to the 5000 Level.
- A campaign of scaling and installation of mesh and bolts has been undertaken on the 4850 Level.
- Test blasts have been performed adjacent to the cavern sites on the 4850 level.
- Site investigation and testing of rock has been completed on the 4850 Level to support cavern design.

Comments

- There have been delays in the award of design, estimating and construction contracts, procurement is working to increase staff and improve their performance. Refer to the management section for more details.
- Near site preliminary design will not be complete as required for CD-2 approval.
- ARUP (AE) has agreed to maintain the same design team personnel as they transition into the far site final design, even though there has been a significant delay in the start of this contract. This will improve their performance on the final design task.
- CM/GC comments and questions on the design phases are provided as a constructability review, this will improve the efficiency and quality of construction.
- Initiating the partnering process with all affected parties is a good step forward and will benefit the design and construction effort as the project proceeds.

Comments –cont'd

- Conventional facilities needs to complete the independent cost estimates for the reliability and pre-excavation tasks, as soon as possible. These estimates are required to verify the cost baseline and will be used as government estimates to compare to the bids from the CM/GC. There are concerns that the bids from CM/GC will be higher than the current AE cost estimates. The AE estimates were completed more than a year ago.
- The CM/GC Option 1A award is needed for any CM/GC construction to start on the far site. Conventional facilities and procurement should develop a detailed plan on how to get this awarded, in order to get construction started as soon as possible. The current plan to have bids for almost all tasks prior to awarding Option 1A, will delay the start of the early tasks.

Comments - Far Site

- Site investigation has validated the good quality of the cavern host rock.
- The upgraded Ross shaft infrastructure/ground support systems will provide for reliable cage/skip operation for the Excavation/BSI contracts and installation work.
- Ground support level on 4850 has been improved significantly.
- Additional, larger scale test blasts may be needed to help optimize Contractor's performance (fragmentation, smoother walls, less over-break).
- CM/GC is focused on coordination of their subcontractor activities, and providing a heads-up on their self-performed portal/tunnel blast work.
- Commissioning time will be needed for some of the Waste Rock Handling components (Skips, Crushers, Pipe Conveyor).
- Crushers conditions are unknown and related scopes-of-work to refurbish are uncertain, as noted in risk register.
- Tramway is accessible and construction should be accelerated to take advantage of Spring-Fall 2018 weather conditions
- The Lead community should be briefed on the likely uptick in activities prior to the multiple pre-excavation activities starting-up in the near future. In particular a heads-up on portal/tunnel blasting activities would be beneficial.

Comments - Near Site

- Need to determine the Near Detector Hall footprint to allow for Near Site (Shafts) investigation work to be completed this year, and allow for efficient start of the design in 2019.
- Firm-up design input for next phase of design by advancing requirements (committees, SME's, technical studies) for key design elements such as water management around Absorber, Decay Pipe, and confirm levels of differential settlement along the beamline in till/weathered rock.
- Advanced level of Conceptual Design work combined with application NuMI experience can support a tailored approach to the achievement of CD-2.

Recommendations

1. The project will not be able to complete the near site preliminary design prior to approval of CD-2. This should be added to the tailoring section of the preliminary project execution plan (PPEP).
2. The project should develop a detailed plan to award the CM/GC Option 1A in a timely manner in order to start their field work on the early pre-excavation tasks as soon as possible. Preparation of the independent cost estimates for these tasks should be a high priority.
3. Ensure that the Near Detector Hall footprint is finalized in time to support the completion of site investigation work this year.

1. Is the project making sufficient progress to give confidence that CD-2 can be achieved by December 2019? Are there adequate resources in place to complete the work needed for CD-2? Yes

6. Are all ES&H organizations, plans, and resources adequate to effectively address all aspects of ES&H for all project activities at all project locations? Depends

8. Has the project responded appropriately to recommendations from past reviews? Yes

- **Findings**
- Required documentation to support CD-2 is current: Preliminary Hazards Analysis Report , QA Plan, Security Vulnerability Assessment Report, NEPA & FONSI issued for Far and Near Sites, Integrated Safety Management Plan, Construction Safety & Health Plan.
- The underground ODH analysis has taken into consideration design changes to the detector caverns and although preliminary, addresses all ODH risks. ODH classification ≤ 1 for all shafts, drifts and caverns. The ODM system design is now on the Project scope.
- The CM/GC (KAJV) is on board at the Far Site and have submitted their draft Site Specific Safety Plan
- The sequence of safety related incidents and subsequent review at the Far Site that preceded today, allowed us to look closely at proposed work activities needing to be completed before underground rock excavation and in general the safety culture.
- The Project has a dedicated ESH professional based at SURF to interact closely with their staff and CM/GC.
- A realistic and dependable radiological analysis of the near site facilities has been performed. There is some optimization to be completed. The Fermi RSO is fully onboard with these efforts.

- **Comments**
- LBNF and SURF have defined a number of facility and infrastructure reliability and construction projects. These projects are intended to reduce the risk of equipment failure resulting in construction delays and therefore, must be completed prior to the start of the main project excavation. There is a lot of work to do. As these are all time critical, there may be a tendency for the schedule to push the work needed to be done, which in turn may drive people to take increasing risks to meet deadlines, safety may suffer during a compressed work schedule.
- An ODH analysis for the introduction of inert gasses into the Target Chase and Decay Pipe has been performed, leading to a ODH hazard classification of ≤ 0 for the building which may see occupancy.
- There was discussion on the proposed tentative re-start plan for limited and full activities within the Ross Shaft, but divergence on how to get there exists.
- The ES&H staff assigned to the Project are experienced and competent. Additional ES&H support from FNAL, Partner labs. and SURF are available and being effectively used in evaluating and developing designs and operating plans. Institutional ESH commitment and support availability, as already demonstrated, is a priority for FNAL and the project.

- **Comments**

- There have been questions raised whether the cryostat vessel is required to undergo a pneumatic test once installed and before the introduction of liquid Argon. FNAL has established a panel to review the hazards and risks associated with the difference between established policy and CERN's position (which is not to perform a pneumatic test). The panel's goal is to reach a shared understanding with CERN on the safest path forward regarding the proposed pressure test of the DUNE cryostat. Should a shared understanding not be reached, the laboratory has a number of options available to resolve the dispute.

- **Recommendations**

1. Review KAJV draft Site Specific Safety Plan for Far Site work to ensure it addresses all hazards identified in the Hazards Analysis Report and assumptions made in the Environmental Assessment. (August 2018)
2. Develop a plan that ensures routine interaction by management with staff that actively monitors the health of the SURF and LBNF Far Site safety programs to ensure they are not compromised by schedules. (June 2018)
3. The Project, SURF and DOE management staff should clearly define, document and agree (scope, approval authority, hold-points) on a path forward for the proposed re-start plan for limited and full activities in the Ross Shaft. (Now)

1. Is the project making sufficient progress to give confidence that CD-2 can be achieved by December 2019? It's possible but things have to fall in place. Are there adequate resources in place to complete the work needed for CD-2? The challenges that have occurred in the past will have to be resolved (safety, procurement, etc.)
7. Is the LBNF/DUNE Project being appropriately and effectively managed, including risk and contingency? Yes, contingency may need further consideration due to identified risks and uncertainties. Does the tailoring strategy provide concrete benefits in lowering the risk or cost and improving the schedule without significant management complications? The CD-3a has helped initiate the critical path activities at the far site and initiate priority work.
8. Has the project responded appropriately to recommendations from past reviews? Not entirely, did not update all of the cost estimate information due to lack of funding understanding (previous review committee recommendation).

6. Cost and Schedule

Findings:

- **Preliminary performance baseline:**
  - TPC cost range $1,260M to $1,860M (Point Estimate $1,564M)
  - Project completion (CD-4) is projected at September 2030, with 5 months of schedule contingency from the project's early finish date (3% on remaining schedule) with a proposed change to 42 months (29% on remaining schedule)
  - Cost contingency is $248,663k (22% on remaining work but 16% on estimate to complete) with a proposed change to $381,500K (32% on remaining work)
  - The EAC is $1,377.8M with the proposed change to contingency ($381.5M) would result in a TPC need of $1,759.4M (of which $144M project identified directed changes that includes $88M due to funding profile changes, still within cost range)
  - Limited scope contingency has been identified within the project Contingency Analysis and Plan document (1 item – not doing the SURF reliability projects) - not realistic
- **Tailoring strategy for CD-2**
  - Due to funding being less than expected this will cause delays to the Near Site design, so decreased design maturity and increased risk will be present at the CD-2 stage.

6. Cost and Schedule

- **Funding profile has changed from the last OPA review as result of the FY18 continuing resolution and based on $50M vs. $55M (budget not out yet, maybe better).**
  - Slower ramp up of funding
  - 102 implemented changes, dominated by directed changes (since last review)
  - Added 35 months to project's early completion (funding profile questions)
  - TPC has increased from $1,536M to $1,564M
  - Early completion (CD-4) was August 30, 2029 now March 30, 2030
- Profile ramps more slowly than anticipated at CD-3a, increases TPC
  - Delays Start of detector #1 installation, operation ~1yr; neutrino "beam ready" ~2.5yrs

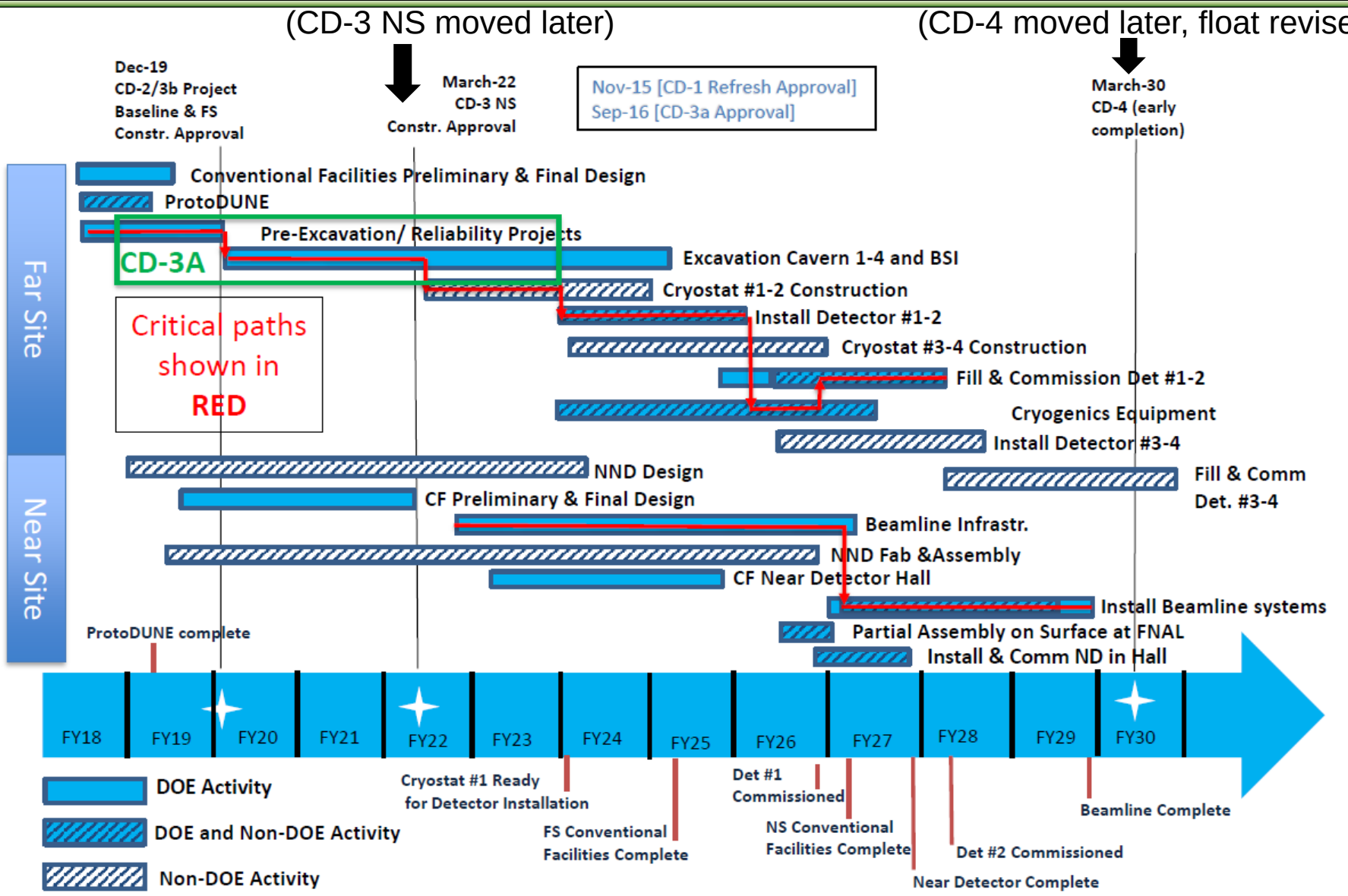
Guidance at CD-3A Approval		Prior Years	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	Total
	OPC	85						2			3	3	93
	TEC	62	45	95	145.1	170	183	202	200	180	147	13.9	1443
	TPC	**147**	**45**	**95**	**145.1**	**170**	**183**	**204**	**200**	**180**	**150**	**16.9**	**1536**

Updated Guidance (Oct 2017)		Prior Years	FY 2017*	FY 2018**	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	Total
	OPC	85		0.1	2	2	2	2	2	2	2	2		101
	TEC	62	50	54.9	113	123	130	162	175	196	210	170	17	1463
	TPC	**147**	**50**	**55**	**115**	**125**	**132**	**164**	**177**	**198**	**212**	**172**	**17**	**1564**

6. Cost and Schedule

- The DUNE International milestone-driven schedule remains in development and is maintained in Microsoft (MS) Project. When complete, the milestone schedule will cover all DUNE detector scope and link to the P6 DOE Far Detector schedule with key interface milestones. If, during monthly statusing, the key milestones between the two schedules do not match then a reconciliation process will take place.
- The LBNF/DUNE project is separated into ten P6 schedules with a total of 10,250 activities and 17,572 relationships. The P6 schedule files are linked by milestones into a single integrated schedule.
- The LBNF/DUNE project has a preliminary baseline containing 87 Control Accounts and 34 CAMs. Most Control Accounts are at WBS Level 4 or 5.
- The project has 67% of its estimates greater than 12 months old.
- Two critical paths for the project runs parallel through the Near and Far Sites with 5 months of schedule contingency between the early finish and CD-4 date.

6. Cost and Schedule



6. Cost and Schedule

- **CD3a includes the following efforts :**
  - FSCF CD-3a Construction Management – CM/GC contract awarded in August 2017
  - Pre-Excavation CD-3a (Pre-excavation) – has started with conveyor design/fabrication started in June 2017
  - Cavern & Drift Excavation CD-3a (Excavation)
  - Buildings & Site Infrastructure CD-3a (BSI)
- **EVMS implemented in June 2017 and appears to be functioning well (8 months).**
  - The project has implemented a functional baseline change control process that has produced 203 change requests since 2015: 180 implemented, 12 rejected and 11 pending. The pending change requests are tracked in the project EAC. Over the past 13 months, 102 changes have occurred with 2/3 of these changes being directed from outside of the project. These changes have resulted in 3.5 years of schedule delay and $152M of cost impact.
  - Pre CD-2 work will also implement some EVMS practices to allow for training and hands on experience with EVMS (Full EVMS will be implemented 6 month prior to CD-2).

6. Cost and Schedule

- **Problems in getting the contracts in places for the initial CD-3a work.**
  - The A/E contract was transferred from SDSTA to Fermilab requiring additional negotiations for liability and flow down clauses from the Fermilab contract. At least a 5-6 month delay.
  - The CM/GC contract award took longer than anticipated (approximately 3 months longer).
- **Near site A/E selection is on going and will take approximately 1 year to be completed.**
- **Safety issues at SURF over the past several months has delayed the work at the Ross Shaft**

6. Cost and Schedule

- **Several of the international contributions have not yet been established**
  - CERN is a major partner in LBNF facility infrastructure at Sanford Lab and is also key to facilitate European engagement in LBNF and DUNE:
    - Signed four partnership protocols on 18 Dec 2015
    - Early commitment to provide first cryostat (valued at $90M U.S. TPC), formalized in addendum to Neutrino protocol in May 2017
    - Facilitating engagement with member countries and European high energy physics community
    - Supporting prototyping effort with short baseline and ProtoDUNEs through CERN's Neutrino Platform
  - UK target and anticipated contributions for the experiment and beamline
  - IHEP (China) has committed to providing 23 corrector magnets, and is discussing decay pipe beam window prototype
  - Exploring contribution opportunities with KEK/Japan on beamline
  - Brazil, India, Italy, and Switzerland are considering in-kind contributions

6. Cost and Schedule

- **Monitoring/managing 161 open/active risks overall; 30 affect FSCF/CD-3a scope; all risks are maintained on Fermi's Risk Registry.**
- **Risk workshops (1 or 2 times per year) last workshop held Dec 2017. Retired 15, added 38 new items, and revised cost impact analysis.**
  - Project reviews risks at its internal Project Management Board meetings each month
- **Project has established an effective risk management process following Fermilab, DOE and industry best practices**
- **Risk mitigation and response plans with clear ownership**
- **Risk data managed in Fermilab-standard web Risk Register**
- **Monte Carlo used to model effects of risks and uncertainties on overall project (schedule) and determine cost and schedule contingency at 90% C.L.**

6. Cost and Schedule

Comments:

- **The project controls team is performing well in light of the funding uncertainties and providing a valuable function to the project team. Responded to 3 of the 4 prior review recommendations adequately and the one not completed was dependent on the uncertainty of the funding profile.**
- **Tracking the EAC at this stage of the project is noteworthy.**
- **The ability of the project to achieve the scheduled CD-2/3b hinges upon receiving the assumed funding profile for FY 2018 – FY 2020. The project's proposed plan (decreased design maturity) to achieve CD-2/3b is less than a typical SC project.**
- **Since 67% of the project estimate is over a year old, the project should update the cost and schedule estimates (including CORE costs and DUNE milestones), prior to requesting an increase to the TPC.**

6. Cost and Schedule

- The project has a cost contingency of 16% (on EAC) which is too low at this stage. The project proposed cost contingency (32%) is more in line, but the need to re-assess estimates and risks could impact the contingency.
- The schedule contingency of 5 months (3%) is too low at this stage. The project proposed a schedule contingency of 42 months (29%) is more in line, but this also could be impacted by re-assessment noted above.
- Assumptions around risk assessment and cost/schedule uncertainty still appear optimistic, particularly in areas such as funding, ES&H, procurement, and international partner performance. The project is encouraged to run the Monte Carlo on the entire project prior to the request to increase the TPC.
- In light of the experience in procurement delays, consider increasing the amount of schedule uncertainty or increase the risk for procurement approval delays.

6. Cost and Schedule

- There is no opportunity to use DOE scope contingency to resolve budget issues on the DOE scope without either identifying additional scope to be provided by non-DOE partners, or not meeting the KPPs or DUNE science objectives. This would support the need for additional cost and schedule contingency.

6. Cost and Schedule

Recommendations:

1. **Perform a comprehensive review of bottom-up cost and schedule estimate (for all project elements) in revising the TPC, which should include adequate cost and schedule contingency, prior to the next OPA Review.**

Cost and Schedule Summary as of January 31, 2018

PROJECT STATUS (Pre CD-2 baseline)		
Project Type	Line Item	
CD-1	Planned: 1Q/FY13	Actual: 10-Dec-12 (A)
CD-1R	Planned: 1Q/FY16	Actual: 5-Nov-15 (A)
CD-3a	Planned: 1Q/FY17	Actual: 1-Sep-16 (A)
CD-2/3b	Planned: 1Q/FY21	
CD-3	Planned: 2Q/FY23	
CD-4	Planned: 4Q/FY30	Proposed (4Q/FY33)
TPC Percent Complete	Planned: 14%	Actual: 14%
TPC Cost to Date	$186 M	
TPC Committed to Date	$193 M	
TPC	$1,564 M ($1,759M proposed)	
TEC	$1,463 M	
Contingency Cost (w/Mgmt. Reserve)	$249 M ($382M proposed)	22% to go (32% proposed)
Contingency Schedule on CD-4	5 months (42 mo. proposed)	3% (29% proposed)
CPI Cumulative	N/A	
SPI Cumulative	N/A	

Findings

- LBNF / DUNE was identified as the number one priority at FNAL by the Lab Director.
- The LBNF / DUNE project has the backing from many parties, including the LBNF / DUNE Collaboration, DOE, and Congress.
- The project is using the CERN / LHC organizational model concerning the use of international collaborations.
- LBNF/DUNE Project has a cost range of $1,260 -$1,860 M.
- The project has identified cost contingency as 22% of BAC.
- The project plans to request CD-2, Approve Performance Baseline, in December, 2019.
- CD-3a was approved to in Sept 2016 to authorize start of initial far site construction for the LBNF/DUNE Project.

Findings

- The DUNE-US part of the Project currently has an ETC of $105M with a contingency remaining of $26M for a DUNE-US TPC to go of $131M. Actuals are $34M through the end of January, giving a TPC of $165M. Within the TPC, $36M, $122M and $7M are currently allocated to the DUNE Project Office, Far Detector and Near Detector, respectively.

- The primary DUNE-US commitment is to the APAs and cold electronics for the Far Detector. The potential commitments to the Near Detector were not described. A Near Detector concept definition is planned for May 2018.

- DUNE Technical Coordination is currently supported by DUNE-US. Funding outside the Project is being sought to support DUNE Technical Coordination after CD-2.

Findings

- FNAL Procurement had 5 staff members retire/resign since June 2017. During that same period they hired 7 new employees, 4 since March 3.
- Two contracts have been selected for DOE Business Clearance Section review. The project is planning for a 6 week turnaround.
- The FSO currently does not have a dedicated contracting officer for LBNF/DUNE. There is a job posting currently out that will provide dedicated project support.
- There have been delays in the acquisition process that subsequently caused loss of schedule time. Of 9 contracts on the LBNF Critical Procurement Schedule, with original finish dates in the past, all 9 were awarded 1 to 6 months past the original finish dates.

Findings

- International planning is proceeding with key partnerships in place. CERN is a major partner on facility infrastructure, detector prototyping and facilitating European engagement. Additional support has been identified from other countries including IHEP/China (Corrector magnets), UK, Brazil, India, Italy, and Switzerland.

- The funding profile ramps up more slowly than anticipated at CD-3a, resulting in an increase in TPC and delays to the start of installation for detector #1 and operations by approximately one year, and neutrino "beam ready" by approximately 2.5yrs.

- Current strategy as agreed to by FNAL, LBNF, and DUNE, is to prioritize the start of Far Site work, and extend Far Site completion in order to begin Near Site work as early as possible. This strategy adds management/escalation costs and reduces remaining contingency.

Findings

- The tailoring strategy includes CD-3a for initial far site construction, CD-2/3b for baseline/far site construction and a future CD-3 to start near site construction.
- There is a plan to add a South Dakota Division as an entity within Fermilab, reporting to the LBNF/DUNE Project Director. Overall responsibilities of the new Division have not yet been determined.
- The Project added a position of Far Site Logistics Manager. The incumbent recently left and a search for a replacement will start soon.
- LBNF/DUNE has added 5 new management staff this past year and currently has 5 openings.
- SURF has experienced a number of safety issues/incidents in the recent past. These have been attributed primarily to work planning shortcomings.
- NEARLY 100 % of Procurement packages submitted to the FSO Contracting Officer for review and approval are returned to Procurement for correction.

Comments

- The Committee strongly endorses the current ESH philosophy to manage the Far Site work as if it is being done at FNAL.

- The Committee supports the use of the CERN / LHC organizational model for a project of this size, complexity, and the incorporation of international collaborators for in kind contributions.

- The Project support of DUNE-US work on the Near Detector is not fully defined and will be decided at a future date, currently anticipated to occur about 6 months before the CD-2 review. The source of funding to support DUNE Technical Coordination for at least FY20 and beyond is uncertain. The DUNE-US plan will be refined based on consortia assignments. These uncertainties need to either be resolved or be reflected in contingency at the time of CD-2.

- Not all risks related to awarding contracts have been added to the risk register, thereby understating cost and schedule exposure to the project.

- The tailoring strategy in the PPEP should be updated to reflect that Near Site design will be only at the conceptual level at CD2.

Comments

- The project has made a good start on identifying the Far Site logistics flow, and on the level of coordination that will be required. However, the committee is quite certain that there will need to be significantly more resources dedicated to this function then is currently planned.

- The Committee feels that the Systems Engineering (SE) core team is too small to cover the needs for the Far Site, Near Site and DUNE. Although the team is expected to be augmented by engineering resources from the Far Site, Near Site and DUNE teams, LBNF/DUNE management should provide a description of the functional SE roles, identify the resources necessary, and fully staff the team.

Comments

- Procurement staff actions on the delayed subcontracts show knowledge deficiencies in the areas of contract type selection and structure, post award contract administration for cost reimbursement contracts, understanding of appropriate FAR Clauses, the need to update procurement documents such as Terms & Conditions for construction contracts, and the structure and proper use of Basic Ordering Agreements.

- Not having sufficiently trained and knowledgeable procurement staff, performing with a sense of urgency, will surely cause additional schedule delays.

- Selection of Procurement staff to specifically meet the requirements of the project in regard to construction contracting, cost reimbursement contracting, subcontract organization, and structure and planning, must be specifically addressed in the hiring process and during comprehensive training of the procurement staff. Prior to posting for the 2 positions currently open on the Procurement Org chart, specific project requirements must be addressed in collaboration with the LBNF Project Manager or designee.

Comments

- Procurement managers and supervisors spend >50% of their time actually doing purchasing which significantly diminishes the management, supervision, and oversight that they are able to provide to staff. Given the turnover in the organization, appropriate management attention is critical.

- The project should organize a Procurement Assist review to include M&O's Heads of Procurement and senior managers who possess extensive relevant experience and knowledge of procurement within DOE labs. They would be able to provide insight into operationally deficient areas, assess staff qualifications and assignments, identify additional training needs, and provide actionable guidance for short and long term improvements.

Comments

- The contingency identified (cost, schedule, and scope) is insufficient considering the project's size and complexity, especially at this phase.

- While the Committee supports the idea of a South Dakota Division to provide support and coordination for all FNAL operational efforts in South Dakota, its responsibilities and authorities need to be clearly defined.

- The Committee heard a number of comments during the Review from various LBNF and DUNE project team members concerning the responsibilities that would/should be taken up by the Host Lab. It is important that the project work with FNAL to develop and socialize a proposal that clearly defines roles and responsibilities for FNAL in that role.

- The Committee remains extremely impressed with the performance of the LBNF Project Manager. However, given the project's sheer size, complexity, and the geographic distances between sites, there is concern that the work load is unreasonably heavy, and ultimately, may be unsustainable.

Recommendations

1. Organize a Procurement Assist review to address the procurement shortcomings by May 2018.
2. Update the planning and associated cost estimates to provide logistics and system engineering support for LBNF and DUNE before the next IPR.
3. Define the requirements for non-DOE contributions necessary for CD2 by Oct 1.
4. Bring the full LBNF and DUNE US scope, cost estimate, contingency (cost, schedule, and scope) and risk analyses, up to date by Oct 1.
5. Propose a revised TPC and funding profile for LBNF/DUNE, including adequate contingency, by Oct 1.
6. The project, the Program, and OPA should agree on a schedule of review(s) to assess progress in executing 3A scope and the entire project's readiness for CD2.

1. Is the project making sufficient progress to give confidence that CD-2 can be achieved by December 2019? Are there adequate resources in place to complete the work needed for CD-2? The project team has made significant progress, however, obtaining CD-2 approval by December, 2019 is aggressive and will be challenging.

2. Is the DUNE collaboration's plan to complete its technical design by CD-2 reasonable and achievable? Have they identified the resources needed to carry out that plan? Has Fermilab provided the technical and management support to the DUNE collaboration consistent with its host lab role? Fermilab has more to do. In particular, assess the progress by US DUNE in defining US contributions to the DUNE experiment. Considerable progress, but they're not done.

4. Is the work on the scope approved at CD-3a proceeding as planned? No. Are procurements being executed in an efficient and timely manner? Many are not. There are still difficult personnel, performance, and staffing issues to be addressed.

7. Is the LBNF/DUNE project being appropriately and effectively managed, including risk and contingency? While we have seen evidence of significant technical progress, the number and severity of the challenges that have arisen during the last year (procurement issues with resultant long schedule delays, heavy contingency usage, safety issues, etc.), causes the Committee to have concerns as to management's effectiveness during this period. Does the tailoring strategy provide concrete benefits in lowering the risk or cost and improving the schedule without significant management complications? It does improve the schedule, but incurs additional risks involving reduced design maturity of the Near Site at CD2.

8. Has the project responded appropriately to recommendations from past reviews? The project team has responded appropriately, however, a key recommendation that "DOE should work with LBNF/DUNE and international partners to better define CD-2 requirements for non-DOE contributions." is still being worked on by the HEP program.